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Center for Electronics and Electrical Engineering

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INTRODUCTION TO APRIL 1984 (2) ISSUE OF THE CEEE TECHNICAL PROGRESS BULLETIN

This is the fourth issue of a quarterly abstract journal covering the work of the National Bureau of Standards Center for Electronics and Electrical Engineering. This issue of the CEEE Technical Progress Bulletin covers the third quarter of calendar year 1983.

ORGANIZATION: Abstracts and citations are arranged by technical topic as identified in the table of contents and alphabetically by first author under each subheading within each topic. Each abstract ends with a telephone number of the individual to contact for more information on the topic; unless otherwise noted, this individual is the first author. Each citation ends with identification of the issue of the Technical Progress Bulletin in which the associated abstract appeared. This issue also includes a calendar of Center conferences and workshops for the remainder of calendar year 1984, an announcement of newly released standard reference materials, and a list of sponsors of the work. SPECIAL NOTE: Because the four issues covering calendar year 1983 are later than intended, the contents of these issues will differ from the original plan of providing abstracts for all papers approved by NBS in a quarter as follows: Each issue will contain (1) abstracts of papers approved for publication by NBS for the appropriate quarter and not subsequently published until calendar year 1984, (2) abstracts of papers approved and published during the quarter, and (3) citations for papers published during the quarter, but for which abstracts have appeared in an earlier issue of the Technical Progress Bulletin. Items in category (1) appear under the subheading "Approved for Publication"; items in categories (2) and (3) appear under the subheading "Recently Published."

Center for Electronics and Electrical Engineering: Center programs provide national reference standards, measurement methods, supporting theory and data, and traceability to national standards.

The metrological products of these programs aid economic growth by promoting equity and efficiency in the marketplace, by removing metrological barriers to improved productivity and innovation, by increasing U. S. competitiveness in international markets through facilitation of compliance with international agreements, and by providing technical bases for the development of voluntary standards for domestic and international trade. These metrological products also aid in the development of rational regulatory policy and promote efficient functioning of technical programs of the Government.

The work of the Center is divided into two major programs: the Semiconductor Technology Program, carried out by the Semiconductor Materials and Processes and Semiconductor Devices and Circuits Divisions in Gaithersburg, MD, and the Signals and Systems Metrology Program, carried out by the Electrosystems Division in Gaithersburg and the Electromagnetic Fields and Electromagnetic Technology Divisions in Boulder, CO. Key contacts in the Center are given on the back cover; readers are encouraged to contact any of these individuals for further information.

Previous special issues: Two special issues of the Technical Progress Bulletin have been published with abstracts for the Signals and Systems Program only, NBSIR 83-2719-1, covering October 1981 through March 1982 and NBSIR 83-2719-2, covering April 1982 through September 1982. NBSIR 82-2636, a special issue of the Semiconductor Technology Program Progress Briefs published in January 1983, listed abstracts of publications from that Program for Federal fiscal year 1982 (October 1981 through September 1982, fifty-third through fifty-seventh quarters of the Program). The new CEEE Technical Progress Bulletin replaces the Progress Briefs series [single copies of 82-2636 are available from the Center, see back cover for address].

Center sponsors: The Center Programs are sponsored by the National Bureau of Standards and a number of other organizations, in both the Federal and private sectors; these are identified on page 11.

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SEMICONDUCTOR TECHNOLOGY PROGRAM

Silicon Materials

Released for Publication

Baghdadi, A., **Discussion on "Precise Evaluation of Oxygen Measurements on Cz-Silicon Wafers,"** submitted to J. Electrochemical Society.

This is a discussion of a paper by Graff, entitled "Precise Evaluation of Oxygen Measurements on Cz-Silicon Wafers," which was published in the Journal of the Electrochemical Society, Vol. 130, No. 6, p. 1378. The equations used by Graff in his paper do not adequately represent the physical situation. This discussion points out the inconsistencies in Graff's approach to the problem.
[(301) 921-3625]

Analysis Techniques

Released for Publication

Chang, T-T., **The Calibration Methods and the Reference Materials in ESR Spectroscopy,** submitted to Magnetic Resonance Review.

This paper reviews the calibration methods and reference materials that have been recommended or have been in use in ESR [electron spin resonance] spectroscopy. Methods for the measurement of microwave frequencies and magnetic fields are briefly mentioned. Methods to measure the Q-factor of a microwave cavity are described. The calculation and measurement of the microwave magnetic field in an ESR resonance cavity are described in detail. Methods for the determination of the concentration of the paramagnetic centers in a sample are described after a discussion of the theoretical background. Precautions and factors that affect the accuracy of this determination are discussed. Reference materials, in 16 groups, are listed. Recipes for preparation of some of these standard samples are also given.
[Contact: Larrabee, (301) 921-3786]

Recently Published

Carver, G.P., **Influence of Short-Channel Effects on Dopant Profiles Obtained from the dc MOSFET Profile Method,** IEEE Trans. on Electron Devices, ED-30, pp. 948-954 (August 1983).

Distortions in the dopant density profile obtained from dc MOSFET measurements due to short-channel effects are not properly predicted by present two-dimensional charge sharing, or charge conservation, models. The comparison of dopant profile data with predictions based on charge conservation models is a powerful technique for evaluating the accuracy of these models.
[(301) 921-3786]

Integrated Circuit Test Structures

Recently Published

Mattis, R.L., **Semiconductor Measurement Technology: A FORTRAN Program for Analysis of Data from Microelectronic Test Structures,** NBS Special Publication 400-75 (July 1983).

A computer program, STAT2, is described which performs the following functions: reads data as a two-dimensional array; calculates mean, sample standard deviation, and median; identifies outliers; calculates replacement values for outliers; makes gray-tone, numerical and contour data maps on a line printer; makes a numerical map on the user's terminal; makes a histogram on a line printer; constructs a data base for examining correlations among various data sets; and searches the data base for correlations using several selective keys. The emphasis is on program usage, and detailed descriptions of the commands are given. Data input requirements are addressed. Guidance regarding several types of program modifications is provided.
[(301) 921-3621]

Process & Device Modeling

Released for Publication

Bennett, H.S., **Dependence of Minority Carrier Lifetime on Doping Density in Heavily Doped Silicon,** submitted to Solid-State Electronics.

The minority carriers determine the essential electrical characteristics of bipolar devices and bipolar-like parasitic paths in field effect devices. The electrical behavior of such devices is frequently described by detailed device models. Among the several input parameters for detailed device models, the dependences of the minority carrier lifetimes as functions of doping density have great uncertainty. Recent results from scattering theory for bandgap narrowing and Fermi energy as functions of doping density are included in the Shockley-Read-Hall expressions for the minority carrier lifetimes. The predicted lifetimes are concave from above with increasing doping for those processing conditions under which the doping and defect densities are not correlated strongly, whereas empirical expressions for the Shockley-Read-Hall lifetimes are convex with increasing doping density. Quantitative comparisons between theory and experiment are not possible because measurements of lifetime versus doping density have uncertainties associated with the separation of the Shockley-Read-Hall and Auger recombination mechanisms. A major finding of this research is that improved measurements are needed for minority carrier lifetime in heavily doped silicon as a function of doping density.
[(301) 921-3541]

Roitman, P., Albers, J., and Myers, D.R., **An Investigation of the Two-Dimensional Shape of Ion-Implanted Regions,** submitted to J. Applied Physics.

The two-dimensional shape of arsenic ion-implanted regions in single-crystal silicon was investigated both experimentally and theoretically. Experimentally, two techniques were shown to have the necessary submicron resolution: a junction etch process and an SEM-induced current collection method. A comparison of junction depths determined by the etch technique and the EBIC techniques with the depths calculated using several amorphous target codes was made. For the case of low temperature (600°C) anneals, the etch technique agrees very well with the junction depths predicted by the amorphous target code due to Winterbon. The lateral junction locations obtained from the etch technique are in good agreement with the predictions of a two-dimensional Monte Carlo code (TRIM) which indicates that the arsenic does not show any significant lateral scattering under mask edges. For the high temperature (1000°C) anneals, the etch and EBIC techniques agree with each other. Comparison with arsenic-diffusion models shows that concentration-dependent effects are important.
[(301) 921-3621]

Recently Published

Bennett, H.S., **Improved Concepts for Predicting the Electrical Behavior of Bipolar Structures in Silicon,** IEEE Trans. Electron Devices, ED-30, pp. 920-927 (August 1983).

Most bipolar device models, based upon doping profiles and upon numerical solutions to coupled, nonlinear equations for semiconductor devices, contain empirical methods for computing the effective intrinsic carrier concentration, n_{ie}, mobility, and lifetime. These methods usually are based upon electrical measurements, assume that the majority hole (electron) mobility equals the minority hole (electron) mobility at high doping densities, use Boltzmann statistics, and assume that the carrier lifetime is much greater than the carrier transit time. More physically correct concepts are reported in this paper and are applied to bipolar

Process & Device Modeling, cont'd.

transistors in silicon. These concepts use the perturbed densities of states and nonparabolic bands which arise from a quantum mechanical description of bandgap narrowing to compute separately n_{ie} and the carrier mobility, use minority carrier lifetimes which agree much better with measured lifetimes in processed silicon, and use Fermi-Dirac statistics. When these concepts are incorporated into a device analysis code such as SEDAN and then used to compute the dc common-emitter gain of two npn transistors, the predicted gains agree very well with the measured gains. In addition, these concepts offer potential improvements in predicting the temperature dependence of the gain.
[(301) 921-3541]

Other Semiconductor Metrology

Released for Publication

Kowalski, P., Lankford, W.F., and Schafft, H.A., **Nondestructive Measurement of Solar Cell Sheet Resistance Using a Laser Scanner,** submitted to IEEE Trans. Electron Devices.

Experimental data have shown that a laser scanner can be used as a probe to make nondestructive measurements of solar cell sheet resistance with an accuracy of several percent. The photovoltaic response from cells with controlled sheet resistance was measured using the scanner and compared with the theoretical predictions made by other workers. Several limitations in this technique are identified and a measurement methodology is suggested.
[Contact: Schafft, (301) 921-3621]

FAST SIGNAL ACQUISITION, PROCESSING, AND TRANSMISSION

Waveform Metrology

Released for Publication

Nahman, N.S., **Status and Future Directions of Picosecond Domain Waveform Standard,** to be published as Chapter 2 in book, Time Domain Measurements in Electromagnetics.

This is Chapter 2 of the book "Time Domain Measurements in Electromagnetics", E.K. Miller, Editor, to be published in 1984. A review of the state-of-the-art of picosecond time domain waveform measurements is presented which includes measurements in both the electrical and optical regions of the electromagnetic spectrum. This review is the latest edition of a series of reviews on high speed pulse measurements compiled by the author since 1967 [1-3]. 130 references, 11 figures, and 4 tables.
[(303) 497-5167]

Stenbakken, G.N., **A Wideband Sampling Wattmeter,** submitted to IEEE Trans. Power Apparatus & Systems.

The design and operation of a wideband sampling wattmeter capable of measuring distorted power signals with fundamental frequencies from 1 Hz to 10 kHz and harmonics up to 100 kHz is described. The microprocessor controlled wattmeter uses asynchronous sampling of the voltage and current signals. The errors associated with this type of operation are described as are various methods of correcting some of these errors. The wattmeter uses both a hardware multiplier-accumulator and a direct-memory-access unit to capture the data. Programmable time delay circuits are used to compensate for differential time delays between the input channels. Performance checks show that measurement uncertainties of less than ±0.1 percent of full-scale range are obtainable.
[(301) 921-2727]

Recently Published

Bell, B.A. and Perrey, A.G., **Peak Conductance Measurements of GaAs Switching Devices,** Proc. SPIE - The International Society for Optical

Waveform Metrology, cont'd.

Engineering, 439, pp. 128-139, SPIE, P.O. Box 20, Bellingham, WA 98227 (1983) [conference San Diego, CA, August 24-26, 1983].

This paper describes the test apparatus and circuitry used to make measurements of pulsed light conductance on samples of high resistivity (10^7 Ω-cm) gallium arsenide switching devices, having nominal 25-μm and 700-μm gap spacings. Differences in conductance are observed on variously grown samples. Maximum peak light conductance obtained was ≈2 millisiemens for an effective irradiated optical power on the (25-μm) gap of approximately 130 milliwatts (λ ≈ 850 nm). Comparisons are made between the observed pulse measurements and the pulse waveforms generated by computer simulation using a model based on a theoretical analysis of the relationships between photoconductance and irradiated optical power. [(301) 921-2727]

Schoenwetter, H.K., **AC Voltage Calibrations for the 0.1 Hz to 10 Hz Frequency Range,** NBS Tech. Note 1182 (September 1983).

The development of voltmeters to meet the need for rms voltage measurements in the infrasonic frequency range is discussed as well as the need to trace these measurements to the U.S. legal unit of voltage. A new method for supporting voltage measurements in the 0.1 Hz range was described in a 1979 paper and is discussed further. The principles of the method are embodied in detailed procedures given for calibrating sine-wave voltage standards and rms voltmeters over the frequency range 0.1 to 10 Hz, using the NBS AC Voltmeter/Calibrator. The sine-wave calibrator of this instrument, used for these calibrations, has an accuracy of 0.020 percent over the 0.5-mV to 7-V range. [(301) 921-2727]

Microwave and Millimeter-Wave Metrology

Recently Published

Kamper, R.A. and Hoer, C.A., **Millimeter Wave Standards at the National Bureau of Standards (NBS),** Proc. SPIE - The International Society for Optical Engineering, 423, pp. 144-146, SPIE, P.O. Box 20, Bellingham, WA 98227 (1983) [conference San Diego, CA, August 22-24, 1983].

This paper describes briefly the standards and measurement systems that are maintained at NBS to provide calibration service in the ranges 26 to 40 GHz, 55 to 65 GHz, and at 95 GHz. The measurement systems range in degree of automation from manually tuned reflectometer and attenuation measurement systems to automated single and dual six-ports. Plans to complete the coverage of the range from 26 GHz to 75 GHz and to extend the range beyond 100 GHz are discussed. [(303) 497-3535]

Optical Fiber Metrology

Recently Published

Day, G.W., **Birefringence Measurements in Single Mode Optical Fiber,** Proc. SPIE - The International Society for Optical Engineering, 425, pp. 72-79, SPIE, P.O. Box 20, Bellingham, WA 98227 (1983) [conference San Diego, CA, August 22-24, 1983].

Because their cores are not perfectly circular or because of stress, inherent to the structure or externally applied, practical single-mode fibers are birefringent. These sources of birefringence are reviewed briefly. A simple model for the fiber consists of a combination of one linearly birefringent element and one circularly birefringent element. Depending on the magnitude of the birefringence, different techniques of evaluating the parameters of the model may be suitable. Several methods appropriate for fibers of low and high

Optical Fiber Metrology, cont'd.

birefringence are described and some of their advantages and disadvantages outlined.
[(303) 497-5204]

Other Fast Signal Topics

Recently Published

Phelan, R.J., Larson, D., Frederick, N.W., and Franzen, D.G., **Submicrometer Interdigital Silicon Detectors for the Measurement of Picosecond Optical Pulses,** Proc. SPIE - The International Society for Optical Engineering, 425 (Single Mode Optical Fibers), pp. 207-211, SPIE, P.O. Box 20, Bellingham, WA 98227(1983) [conference August 22-24, 1983].

Interdigital silicon Schottky barrier diodes have been evaluated for picosecond pulse measurements. Structures with clearly defined receiving apertures and submicrometer contact spacings were created with electron beam lithography. The detectors exhibit saturation currents corresponding to the absorbed optical power. Impulse response widths were less than 50 ps, and response maps yielded uniform patterns. A peak quantum efficiency of over 30 percent was obtained, and the usable spectral responsivity extends beyond 2 m.
[(303) 497-3696]

Young, M., **Linewidth Measurement by High-Pass Filtering--A New Look,** Applied Optics, 22, No. 13, pp. 2022-2025 (1 July 1983).

Earlier workers have noticed that high-pass filtering produces a sharp dark line in precisely the location of the geometrical image of an edge. They proposed using this fact as an aid in measuring linewidth in microscopy but found that the other edge of the line caused significant error. In this paper, I examine that error as a function of normalized linewidth and normalized spatial-filter width and find that it may be limited to ±5% or so, provided that the spatial filter subtends between 0.25 and 0.3X the numerical aperture of the objective and that the linewidth exceeds about twice the resolution limit.
[(303) 497-3223]

ELECTRICAL SYSTEMS

Power Systems Metrology

Recently Published

Hebner, R.E., **Development of Power System Measurements -- Quarterly Report October 1, 1982 to December 31, 1982,** NBSIR 83-2755 (September 1983).

This report documents the progress on five technical investigations sponsored by the Department of Energy and performed by the Electrosystems Division, the National Bureau of Standards. The work described covers the period from October 1, 1982 to December 31, 1982. The report emphasizes the calibration of instruments designed to measure the 60 Hz electric and magnetic fields in biological exposure facilities, the measurement of the rate of decomposition of SF_6 in positive dc-corona discharges, and in the measurement of space charge in transformer oil between 100°C and 150°C.
[(301) 921-3121]

Kelley, E.F. and Hebner, R.E., **Electro-Optic Measurement of the Electric Field Distribution in Transformer Oil,** IEEE Trans. Power Apparatus & Systems, PAS-102, No. 7, pp. 2092-2097 (July 1983) [abstract appeared on page 7 of May 1983 TPB (NBSIR 83-2719-1].

McKnight, R.H. and Kotter, F.R., **A Facility to Produce Uniform Space Charge for Evaluating Ion Measuring Instruments,** IEEE Trans. Power Apparatus & Systems, PAS-102,

Power Systems Metrology, cont'd.

pp. 2349-2357 (July 1983) [abstract appeared on page 16 of July 1983 TPB (NBSIR 83-2719-3)].

Ramboz, J.D. and McAuliff, R.C., **A Calibration Service for Wattmeters and Watthour Meters**, NBS Technical Note 1179 (July 1983).

An NBS calibration service for wattmeters and watthour meters is described. The service offers measurements of percentage registration for watthour meters and percentage correction for wattmeters over a range of voltages and currents at a frequency of 60 Hz. Measurements are limited to power factors of 1.0 and 0.5, leading and lagging. The Measurement Assurance Program (MAP) for electric energy is discussed. National standards for electric energy, NBS services, special equipment and instruments, and measurement methods and procedures are described as are error estimates and quality control. A representative Report of Calibration is included.
[(301) 921-3121]

Pulse Power Metrology

Recently Published

McKnight, R.H. and Schoenwetter, H.K., **Evaluation of Transient Measurement Methods in Gas-Insulated Transmission Lines**, NBSIR 83-2753, (August 1983).

Capacitive sensors suitable for measuring transients in gas-insulated transmission lines have been studied in the laboratory. Measurements of the step response of three different sensors were made with a test line using both low voltage (200 V) and high voltage (10 kV) signals. Sensor designs were based on those used in pulse power measurements. The use of active electronics at the sensor output in the form of fast buffer amplifiers or commercial FET input probes was investigated as a means of extending low frequency cutoff. Lumped parameter models were used to provide theoretical analysis of experimental results.
[(301) 921-3121]

Superconductors

Recently Published

Fickett, F.R., **Conductors for Advanced Energy Systems Annual Report 1982**, INCRA Research Report, Paper No. 321A, pp. 1-97, International Copper Research Association, 708 3rd Ave., New York, NY 10017 (August 1983).

The coppers that are almost always chosen for stabilizing superconductors are the oxygen-free grades, usually CDA 102 in the U.S. Since the copper undergoes considerable deformation and thermal treatment in the production of the conductor, it is essential that information be available that will allow the magnet designers to determine the amount of copper required for optimum protection and maximum current density. It is this problem that is addressed in the experimental program reported here. Data are presented on the resistance and magneto-resistance at 4 K of various coppers and how these parameters are affected by temper, anneal, and strains induced by several methods.
[(303) 497-3785]

ELECTROMAGNETIC INTERFERENCE

Recently Published

Bensema, W.D., **Handbook for Broadband Isotropic Antenna System Volume 1 -- Operations Manual**, NBSIR 83-1693 (July 1983).

This manual described the equipment, operation, and maintenance procedures to support the broadband isotropic antenna system developed by the National Bureau of Standards for making EMI measurements in the frequency range from 10 kHz to 18 GHz. [The term "isotropic" as used in this handbook refers to the ability of the system to synthesize an isotropic

Electromagnetic Interference, cont'd.

response from several measurements, rather than to the pattern of a single antenna structure.]

The system uses isotropic broadband antennas, a low power microcomputer, antenna switching units, commercially available receivers, and associated cabling. The system automatically switches antenna elements, computes the total scalar sum of the existing field strength, and automatically logs time, frequency, signal strength, and system configuration. The system reduces the number of personnel required to make searches for EMI, and includes a mode for unmanned monitoring.
[(303) 497-3465]

Crawford, M.L., **Comparison of Open-Field, Anechoic Chamber and TEM Cell Facilities/Techniques for Performing Electromagnetic Radiated Emissions Measurements**, Record, IEEE 1983 International Symposium on Electromagnetic Compatibility, pp. 413-418 (1983) [conference Arlington, VA, August 23-25].

This paper compares the results of measurements performed at discrete frequencies between 30 MHz to 300 MHz using a spherical dipole reference standard radiator to evaluate: 1) a (6.0 x 9.0)-m ground screen open-field site, 2) a (3.0 x 4.88 x 6.1)-m anechoically quieted shielded enclosure, and 3) a (2.8 x 2.8 x 5.6)-m anechoically quieted TEM cell for use in measuring radiated rf emissions from electronic equipment. The paper briefly describes each facility, the test techniques, and the test configuration used. The results given provide a comparison of the radiated measurement uncertainty anticipated from a point source radiator for each facility, when all known correction factors (assuming far-field conditions) are applied.
[(303) 497-5497]

FitzGerrell, R.G., **E-Fields Over Ground**, Record, IEEE 1983 International Symposium on Electromagnetic Compatibility, pp. 6-9 (1983) [conference Arlington, VA, August 23-25].

Equations from a classic paper by K.A. Norton are used to generate plots of electric field strengths versus distance, at fixed heights above ground, from horizontal and vertical dipole antennas. These data are used to estimate the strength and pattern of electric fields over plane perfect and imperfect ground test sites. A preliminary measurement effort, designed with the aid of these calculated data, indicates that the half-wave dipole antenna factor is essentially independent of distance from short, horizontal dipole, E-field sources over a plane metal ground screen at separation distances of 1 to 10 m over the frequency range 30 to 1000 MHz. Measured data also show the influence of the transmission line on the vertically polarized dipole antenna factor and source antenna E-field combined (combined because measurements cannot separate transmission line effects on dipole input impedance and antenna pattern).
[(303) 497-3737]

Liu, B-H., Chang, D.C., and Ma, M.T., **Design Consideration of Reverberating Chambers for Electromagnetic Interference Measurements**, Record, IEEE 1983 International Symposium on Electromagnetic Compatibility, pp. 508-512 (1983) [conference Arlington, VA, August 23-25].

Two aspects pertaining to the design of rectangular, mode-stirred or mode-tuned reverberating chambers are considered in this paper, namely the spectral distribution of resonant modes and the composite quality factor of the chamber. After obtaining the total number of eigenmodes with eigenfrequencies less than or equal to any given value and an exact expression for the mode density, the solution of the total number of modes is seen to consist of smooth and

Electromagnetic Interference, cont'd.

fluctuating parts. Then simple criteria are identified for designing this shape of the chamber. To take into account the conductor loss of the walls, a simple, closed-form composite quality factor is also proposed. These results are useful as design guidelines of reverberating chambers.
[(303) 497-3800]

Liu, B-H., Chang, D.C., and Ma, M.T., **Eigenmodes and the Composite Quality Factor of a Reverberating Chamber,** NBS Technical Note 1066 (August 1983).

The total number N of electromagnetic eigenmodes, with eigenfrequencies not greater than some given value, which can exist inside a rectangular mode-stirred or mode-tuned reverberating chamber is important in that it reveals how many modes can be available at an operating frequency for the "stirring" or tuning purpose. This is calculated analytically via a lattice-point counting technique in the k-space (k = wave number), leading to an exact expression for N, which can be split into a smooth component and a fluctuating part. The former contains, in addition to Weyl's volume term, an edge term as a second-order correction. The latter is sensitive to the dimensions of the chamber. Simple design criteria are then derived in view of the number of available modes and the uniformity of their distribution. To take into account the ohmic loss in metal walls of the chamber, a composite Q-factor is also proposed for design purposes. This is achieved by taking a suitable average of 1/Q-values of all possible modes within a small frequency interval. Comparison with numerical Q-values for individual modes shows that the composite Q can be used as a practical design parameter.
[Contact: Ma, (303) 497-3800]

Wilson, P.F., Chang, D.C., Ma, M.T., and Crawford, M.L., **Theoretical and Experimental Analysis of Coupling Characteristics of Dual TEM Cells,** Record, IEEE 1983 International Symposium on Electromagnetic Compatibility, pp. 513-517 (1983) [conference Arlington, VA, August 23-25].

A standardized method for quantitatively evaluating a test material's shielding effectiveness is a topic of widespread interest to the electromagnetic interference community. Field penetration through materials may significantly affect the designed performance of devices contained inside the material. To take advantage of the known properties of a TEM cell, a shielding effectiveness measurement procedure based on coupling power between a pair of TEM cells via a material-laden aperture is being proposed in industry. No theoretical basis, however, has been formulated to provide guidelines for properly designing such a dual TEM cell structure and for interpreting the measured results. The theoretical analysis of, and experimental results for, an unloaded aperture case (i.e., with no material present) are presented to provide a better understanding of the structure's basic properties.
[(303) 497-3842].

CEEE CALENDAR

1984

April 30 - May 4 (Boulder, CO)

NBS Noise Measurement Seminar. The course is intended for practicing noise metrologists and technical managers responsible for systems for which accurate noise measurements are important. The seminar introduces and describes reference noise sources, noise measuring systems, and the problems of characterizing and measuring noise in passive components, amplifiers, and satellite earth terminals. Class examples will specifically address the measurement of noise power; amplifier noise; and antenna system noise, including measures such as noise equivalent flux, the ratio of system

CEEE CALENDAR, cont'd.

gain to system noise temperature G/T, and the ratio of carrier power to noise density C/kT.

The course will cover both theory and practice of precision noise measurements; the practical lectures are designed to stand alone and to be understood by those having minimal mathematical background.
[Contact: Sunchana Perera (303) 497-3546]

June 18-21 (Gaithersburg, MD)

Power Electronics Specialists Conference. Co-sponsored by the Power Electronics Council of the Institute of Electrical and Electronics Engineers and the National Bureau of Standards, the Conference is intended to provide a venue where specialists in circuits, systems, electron devices, magnetics, control theory, instrumentation, and power engineering may discuss new ideas, research, development, applications, and the latest advances in power electronics.

The Conference will incorporate six technical sessions (on converter circuits, converter systems, converter control, motor drives, power components, and modeling and analysis techniques), a one-day tutorial on Electromagnetic Compatibility in Power Systems, and three special "rap sessions" (EMI, RFI, and Noise: Fact or Fiction; Emerging Power Semiconductors: Positive and Negative Attributes; and Future Trends in Aircraft Power Electronics and Electrical Actuators).
[Contact: Sandra B. Kelley (301) 921-3541]

August 28-30 (Vail, CO)

Short Course on Optical Fiber Measurements. This course is addressed to scientists and engineers who are involved in fiber characterization. The course will emphasize concepts, techniques, and apparatus used in measuring the engineering parameters of telecommunication-grade fibers. A degree in electrical engineering or physics is assumed. The course will last three days with 18 hours of class time.
[Contact: Robert L. Gallawa (303) 497-3761]

October 15-17 (Boulder, CO)

Symposium on Optical Materials for High Power Lasers. The Symposium is the principal forum for the exchange of information on the physics and technology of materials for high-power lasers. Topics to be discussed include new materials, bulk damage phenomena, surface and thin film damage, design considerations for high-power systems, and fundamental mechanisms of laser-induced damage. The series of conference proceedings resulting from these annual symposia has collectively become the principal repository of information on optics for all aspects of high-power/high-energy lasers, including, in addition to the subjects given above, environmental degradation, durability, fabrication, material growth and deposition processes, and testing.
[Contact: Aaron A. Sanders (303) 497-5341]

NEW STANDARD REFERENCE MATERIALS

Two new Standard Reference Materials (SRMs) for calibrating equipment used to make spreading resistance measurements have been released by the Semiconductor Materials and Processes Division to the NBS Office of Standard Reference Materials for sale to the public. SRM 2526 applies to (111)-oriented p-type silicon surfaces and SRM 2527 to $\overline{(111)}$-oriented n-type silicon surfaces. Each SRM consists of a set of about 15

STANDARD REFERENCE MATERIALS, cont'd.

specimens (number of specimens varies depending on availability of material of appropriate resistivities) of silicon, 6 x 12 mm in area and mounted on beveled metal blocks for convenient use in calibrating commercial spreading resistance equipment. These silicon chips have resistivities ranging from about 0.001 to 200 Ω•cm. Slices are measured before dicing; only slices having uniformity of resistivity within predetermined bounds are selected. The uncertainties in resistivity range typically from 2 to 5 percent for p-type specimens and from 4 to 10 percent for n-type. Two companion SRMs for (110) silicon surfaces are about to be released (2528, p-type and 2529, n-type).

Note on Publication Lists: Guides to earlier as well as recent work are the publication lists covering the work of each division. These lists are revised and reissued on an approximately annual basis and are available from the originating division [publications from the Semiconductor Technology Program are covered in a single list, available from either Semiconductor Division].

SPONSORS OF WORK REPORTED IN THIS ISSUE

National Bureau of Standards
Department of Defense
- Defense Advanced Research Project Agency; Calibration Coordination Group; Defense Nuclear Agency
- U.S. Air Force
  - Bolling Air Force Base; Kirtland AFB; Newark Air Force Station; Space Division; Wright-Patterson AFB
- U.S. Army
  - Aviation Research & Development Command; Fort Huachuca; Fort Monmouth; Materials & Mechanics Research Center; Redstone Arsenal
- U.S. Navy
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All technical information included in this document has been approved for publication previously.

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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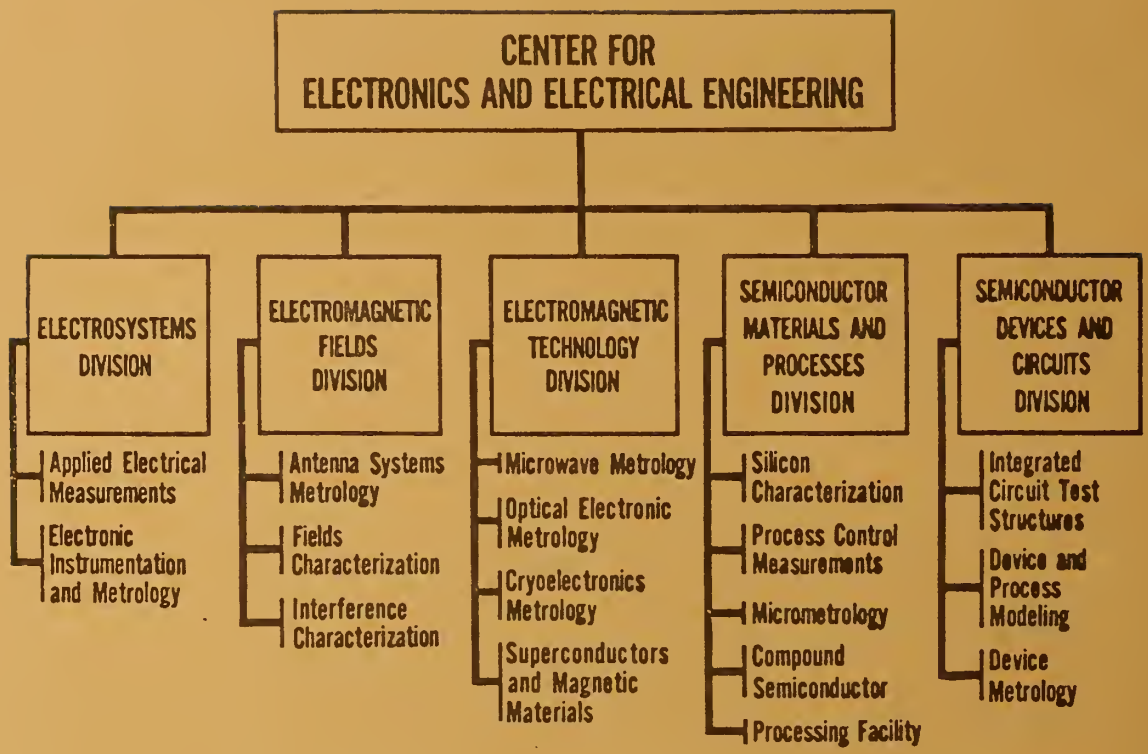

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